~~a direction substantially normal to the upper surface of the substrate body.~~

45. The optical apparatus according to claim 44 wherein the beam steering assembly is placed at a predetermined orientation within the upper cavity for controllably altering the optical path of an impinging beam in at least one direction that is emanating from or propagating towards the primary optical path.

46. The optical apparatus according to claim 44 wherein the primary optical path is a waveguide.

47. The optical apparatus according to claim 44 wherein the primary optical path is a groove for accommodating the passage of the light beam.

48. The optical apparatus according to claim 47 wherein the groove is a V-groove.

49. The optical apparatus according to claim 48 further comprising a primary optical element for accommodating the light beam wherein the primary optical element is provided within the V-groove.

50. The optical apparatus according to claim 49 wherein the primary optical element is selected from the group consisting of optical waveguides, refractive optical elements, reflective optical elements, phase optical elements, light detectors, beam splitters, lasers, light emitting diodes, incandescent light sources, fluorescent light sources, natural light sources, and plasma light sources.

51. The optical apparatus according to claim 44 wherein the substrate body is formed of a crystal having a differential etch rate between different crystallographic planes.

52. The optical apparatus according to claim 44 wherein at least one cavity is anisotropically etched into the substrate body.

53. The optical apparatus according to claim 44 further comprising a cover plate for covering

at least one cavity and an adjacent surface of the substrate body.

54. The optical apparatus according to claim 53 wherein the cover plate is formed from a material with at least one characteristic selected from the group consisting of optically opaque, transparent, translucent, electrically conductive, and electrically insulative.

55. The optical apparatus according to claim 44 further comprising:

a hinge for flexibly connecting the beam steering assembly with an upper edge of the upper cavity that is not coincident with the primary optical path;

wherein the beam steering assembly includes at least one reflective surface such that the beam steering assembly is disposed within the upper cavity so that an impinging beam of light emanating from the primary optical path is controllably deflected in the same general direction the upper cavity is facing and wherein a beam of light entering from the same general direction the upper cavity is facing is controllably deflected towards said primary optical path.

56. A hybrid optical steering system comprising:

a single substrate body defined by an upper surface and a lower surface and formed with at least one cavity including an upper cavity formed on the upper surface of the substrate body and a primary optical path for accommodating the passage of a light beam aligned in a predetermined orientation with the upper cavity;

a lower cavity formed on the lower surface of the substrate body having a predetermined alignment with respect to the upper cavity;

a suspended bridge spanning the primary optical path at a juncture between the primary optical path and the upper cavity;

a beam steering assembly having a steerable element positioned substantially adjacent the upper cavity for controllably directing the light beam through at least a portion of the substrate

body; and

a hinge for flexibly anchoring the beam steering assembly to the suspended bridge wherein the beam steering assembly has at least one reflective surface and is rotated towards the upper cavity so that an impinging beam of light emanating from the primary optical path is controllably deflected in a direction generally from the upper cavity to the lower cavity and an impinging beam of light entering from the lower cavity is controllably deflected in a direction generally from the lower cavity to the upper cavity towards the primary optical path.

57. The optical apparatus according to claim 56 further comprising: a secondary optical element for accommodating a beam of light disposed within the lower cavity of the substrate body;

means for aligning the secondary optical element within the lower cavity so that the secondary optical element is substantially centered in the lower cavity and the optical axis of the secondary optical element is aligned at a predetermined angle with respect to the lower surface of the substrate body.

58. The optical apparatus according to claim 57 wherein the secondary optical element is selected from the group consisting of optical fibers, refractive optical elements, reflective optical elements, phase optical elements, light detectors, beam splitters, lasers, light emitting diodes, incandescent light sources, fluorescent light sources, natural light sources, and plasma light sources.

59. A micro-machined steerable optical device comprising:

a single substrate body defined by an upper surface and formed with at least one cavity including an upper cavity formed on the upper surface of the substrate body, and a primary optical path for accommodating the passage of a light beam aligned in a predetermined

orientation with the upper cavity;

a beam steering assembly having a steerable element positioned substantially adjacent to the upper cavity for controllably directing the light beam through at least a portion of the substrate body; and

a frame and a gimbaled micromirror nested in a set of gimbaled hinges that provides an axis of rotation of the gimbaled micromirror with respect to the frame and wherein the frame holds the set of the gimbaled hinges and is connected to the upper surface of the substrate body so that the beam steering assembly may deflect a light beam in a direction towards the upper surface.

60. The steerable optical device according to claim 59 further comprising:

a plurality of independently addressable electrodes disposed about the gimbaled micromirror for positioning the micromirror in direct electrical communication with a plurality of electrical lines; and

electronic control means in communication with the electrical lines for electrically driving the gimbaled micromirror to a predetermined angular orientation with respect to the frame.

61. The steerable optical device according to claim 59 wherein the gimbaled micromirror is defined by an electrically conductive and optically reflective surface and further includes a conductive film.

62. The steerable optical device according to claim 61 further including an insulating film covering at least a portion of the gimbaled micromirror.

63. A micro-machined steerable optical device comprising:

a single substrate body defined by an upper surface and formed with at least one cavity

including an upper cavity formed on the upper surface of the substrate body and a primary optical path for accommodating the passage of a light beam aligned in a predetermined orientation with the upper cavity;

a beam steering assembly having a steerable element positioned substantially adjacent to the upper cavity for controllably directing the light beam through at least a portion of the substrate body; and

a frame and a micromirror nested in a set of hinges that provides an axis of rotation of the micromirror with respect to the frame and wherein the frame holds the set of hinges and is connected to the upper surface of the substrate body so that the beam steering assembly may deflect a light beam in a direction towards the upper surface.

64. The steerable optical device according to claim 63 further comprising:

a plurality of independently addressable electrodes disposed about the micromirror for positioning the micromirror in direct electrical communication with a plurality of electrical lines; and

electronic control means in communication with the electrical lines for electrically driving the micromirror to a predetermined angular orientation with respect to the frame.

65. The steerable optical device according to claim 63 wherein the micromirror is defined by an external surface and is formed with a conductive film adjacent to its external surface and across the at least one set of hinges so that the micromirror is in electrical communication with the electronic control means.

66. A micro-machined steerable optical device comprising:

a single substrate body defined by an upper surface and formed with at least one cavity including an upper cavity formed on the upper surface of the substrate body, and a primary

optical path for accommodating the passage of a light beam aligned in a predetermined orientation with the upper cavity;

a beam steering assembly having a steerable element positioned substantially adjacent to the upper cavity for controllably directing the light beam through at least a portion of the substrate body; and

a frame and a hybrid micromirror nested in at least one set of gimbaled hinges including a relatively outermost set of hinges that provides additional axes of rotation of the hybrid micromirror with respect to the frame and wherein the frame holds an outermost set of the hinges and is connected to the upper surface of the substrate body so that the beam steering assembly may deflect a light beam in a direction towards the upper surface.

67. The steerable optical device according to claim 66 further comprising:

a plurality of independently addressable electrodes disposed about the hybrid micromirror for positioning the micromirror in direct electrical communication with a plurality of electrical lines; and

electronic control means in communication with the electrical lines for electrically driving the hybrid micromirror to a predetermined angular orientation with respect to the frame.

68. The steerable optical device according to claim 66 wherein the hybrid micromirror is defined by an electrically conductive and optically reflective surface and further includes a conductive film.

69. The steerable optical device according to claim 68 further including an insulating film covering at least a portion of the hybrid micromirror.

70. An optical head assembly comprising:

a single substrate body defined by an upper surface and formed with at least one cavity

including an upper cavity formed on the upper surface of the substrate body and a primary optical path for accommodating the passage of a light beam aligned in a predetermined orientation with the upper cavity; and

a beam steering assembly rigidly affixed in a predetermined orientation within at least a portion of the upper cavity having a steerable element positioned substantially adjacent the upper cavity for controllably directing the light beam through at least a portion of the upper cavity.

71. The optical apparatus according to claim 70 wherein the beam steering assembly is rigidly affixed within the upper cavity by chemical bonding with a chemical bonding agent.

72. The optical apparatus according to claim 70 wherein the beam steering assembly is rigidly affixed within the upper cavity by thermal bonding with a thermal bonding agent.

Respectfully submitted,

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